International Journal on Science and Technology (IJSAT)

E-ISSN: 2229-7677 ● Website: www.ijsat.org ● Email: editor@ijsat.org

Matlab/Simulation Testing and Analysis the Overall System Efficiency of Solar PV System Consisting of Dc-Dc Boost Converter and Dc-Ac Inverter Using Mppt Algorithm Technique Based On P&O Method

Nandkishor Jatav[1], Ms. Kumari Ashwini[2]

[1]M.Tech Student, Dept. Of Electrical Engineering, RCERT, Jaipur, Rajasthan, India
[2]Assistant Professor, Dept. Of Electrical Engineering, RCERT, Jaipur, Rajasthan, India

Abstract

Photovoltaic (PV) standalone technologies are becoming increasingly important in both rural and urban areas for applications such as PV solar panels and battery charging. Regarding consequences for the environmental and depletion of fossil fuels, there is a growing tendency toward the usage of renewable energy to the greatest extent possible. In this research paper, the DC-AC inverter is focused. Inverters serve an important part in modern power systems, their performance is required for the use of electrical energy for a variety of domestic and industrial applications. Thus, proposed a single phase inverter that employs pulse with modulation (PWM), the usage of PWM makes it more efficient and superior to ordinary inverters. This research discusses an essential Boost Converter circuit established in MATLAB/Simulink using a continuous DC supply voltage. However, studies are also conducted between the converter directly connect to the PV system and the converter connected using the MPPT (Maximum Power Point Tracking) technique. The MPPT, which is applicable to various methods, can improve the efficiency of panels, including the use of perturb and observe (P&O) method. According to the results, the proposed Boost Converter and inverter-based solar panel accurately simulate module behavior under various situations for simulating the output of a PV system, with an average power conversion overall system efficiency of approx 90-97%, resulting in a significant increase in efficiency.

Keywords: Solar PV System, Boost Converter, Inverter, PWM, MPPT, P&O Method etc.

1. Introduction

Renewable energy sources acquire their supply of energy from the clean and continuous supply of energy in the world around them. Such sources include solar, hydro-power, bio-energy, geothermal etc [1].

Renewable energy sources considered for 22% of total world energy production in 2012. Renewable energy sources, when replaced by fossil fuels, substantially decrease greenhouse gas emissions.

Renewable energies should be sustainable because they derive organically from the current sources of energy in the atmosphere. Renewable energy must be endless and supply environmental offerings and amenities to be considered renewable energy. For example, the production of bio-fuel should not increase net atmospheric carbon dioxide (CO_2), have an adverse impact on the supply of food or deplete biodiversity.

Nonetheless, widely implemented of renewable energy faces a number of challenges, including irregularity caused by weather related fluctuation, the complexities of energy storage, initial capital outlays, and seamless integration into existing electricity systems. It is worth noting, however, that the inexorable march of technological advancement, combined with an increasing public awareness of environmental imperatives, has resulted in significant progress in the global proliferation of renewable energy sources.

Solar energy has several significant advantages, making it an environmentally friendly alternative to traditional energy sources. It stands out from fossil fuels in that it does not emit CO_2, which is a key cause to global warming. This feature is consistent with the desire to limit environmental damage. Furthermore, developments in energy storage technology enable efficient battery storage, improving the stability of solar energy systems and alleviating worries about intermittent availability [2].

Single phase DC-AC inverter are used in a wide variety of applications where load voltage, frequency, or both must be controlled. Single phase induction motors of various designation demand a DC-AC inverter for controlling their torque and speed characteristics. Inverter transform DC into AC power for any sort of system [3, 4].

The most common type of PV array is an inductive connection of multiple panels to provide a higher DC link voltage for main power using a DC-AC inverter. The output voltage wave-forms of ideally inverter ought to be sinusoidal in character, but the wave-forms of suitable inverters are non-sinusoidal. [2, 5-7]. The resonance inverters are thought to reduce electrical losses caused by switch ON and switch OFF while both the current and voltage wave-forms include values greater than zero [8].

An inverter is a device that converts a DC into a sinusoidal alternating current output. An inverter must be built to meet the expectations of an energy home while being efficient during periods of low demand. The inverters efficiency is greatly dependent on its topology, switching device and frequency [9].

In this paper, maximum power point tracking algorithms are important for maximizing energy from photovoltaic systems as they consistently match the operating voltage of solar arrays to the peak power point. The advanced MPPT method uses the P&O technique with established variance for standard current in identifying the overall maximum power point (MPP) [10].

2. System Overview

The PV array is made up of interconnected PV modules that create DC power when exposed to sunlight. In a photovoltaic system with an MPPT based DC-AC inverter, a DC-DC converter is utilized to convert the PV arrays fluctuating DC voltage to a stable DC voltage appropriate for the inverter. This algorithm continuously adjusts the operating point of the DC-DC converter and ensures that the PV panel is working at its MPP under a variety of conditions. The MPPT algorithm controls the DC-DC converter to maximize the greatest power stored in the PV array under different solar irradiation and temperature conditions.

Considering this, the MPPT based DC-AC inverter system is intended to maximize power extraction, voltage management and power conversion. Fig. 1 shows the connection between the solar PV panel to the DC-DC Boost Converter and the DC-AC inverter.

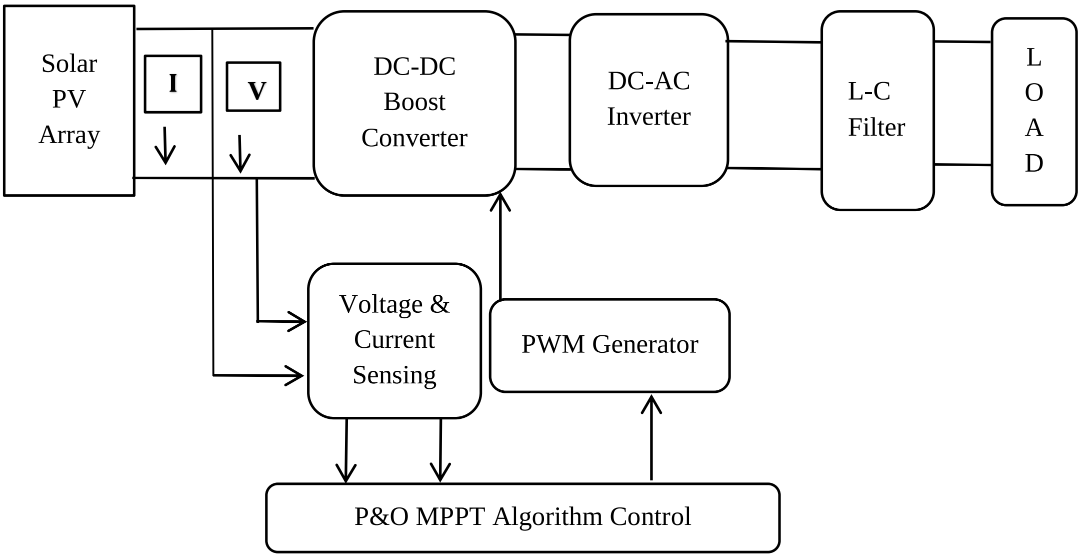


Fig. 1. Solar PV module connect of DC-DC Boost Converter and the DC-AC inverter

3. Basis Topology of DC-DC Boost Converter

In Fig. 2, the topology of a schematic of the DC-DC Boost converter is shown. For numerous situation where a DC voltage need to be increased without first converting it to AC, Boost Converter offer a flexible way to step up DC voltages. Step-up converter known as "Boost Converter" apply an inductor as an energy store device to supplement the DC input source with extra energy to sustain the output.

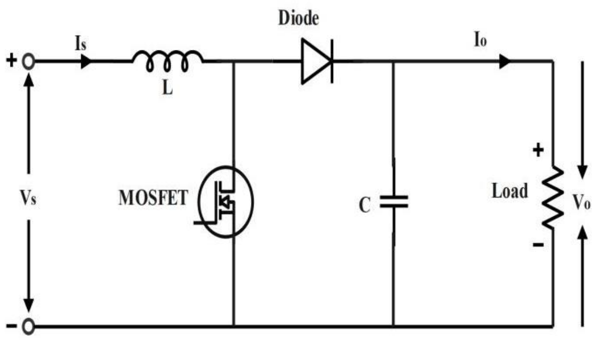


Fig. 2. Schematic of the DC-DC Boost Converter

Modes Of Operation:-

1. Switch (S) is ON and diode (D) is reverse-biased.
2. Switch (S) is OFF and diode (D) is forward-biased.

Mode I: The switch turns ON, and the diode is reverse-biased. Consequently, the switch permits current to pass through it. All of the current will return to the DC input source via the closed circuit, which includes the switch and inductor (L). The circuit diagram for Boost Converter switch is ON shown in Fig. 3.

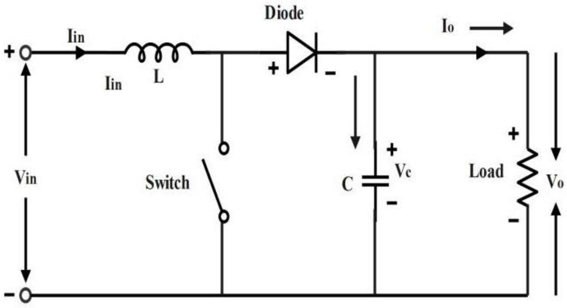


Fig. 3. Boost Converter circuit switch is ON

Mode II: D is forward-biased, while the S is OFF. As a result, switch at diode allows current to flow through it, while S prevents current flow. The circuit diagram for Boost Converter switch is OFF shown in Fig. 4.

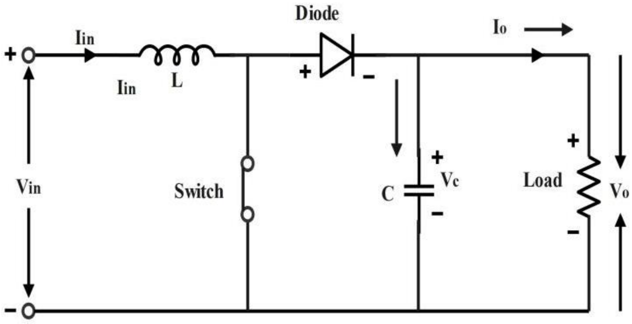


Fig. 4. Boost Converter circuit switch is OFF

The diode enters a forward-biased state when the inductor polarity reverses during the release of energy stored inside it [13]. Thus, it permits current to flow in the direction of the load. Some parameter values for the boost converter are given in Table-I.

TABLE I: Key parameters of DC-DC Boost Converter

Parameters	***Values***
Inductor (L1)	2.5e-3
Capacitor (C1)	1.3e-3
Capacitor (C2)	10e-3
Load (R)	25

4. Inverter

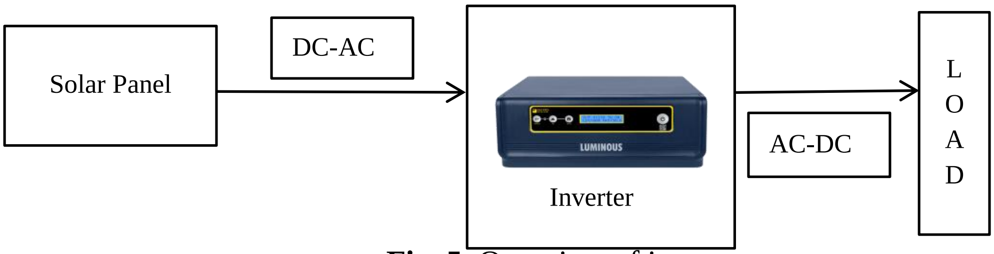


Fig. 5. Overview of inverter

An inverter is an electrostatic device that controls the conversion of direct current (DC) to alternating current (AC). An inverter is a type of electrical power that converts into another type but does not produce any electricity. It consists of several main components, including transistors and metal oxide semiconductor field effect transistor (MOSFET). This device collects the solar panel's output power and then functions as an inverter, converting DC to AC power. An overview of this inverter is shown in Fig. 5.

5. L-C Filter

An L-C filter is a type of electrical filter that filters a signal's frequency components using an inductor and a capacitor (C). These filters are typically used to pass or block specific frequencies, depending on how the circuit is configured. Table II shows several parameter values for the L-C filter. The fundamental advantage of L-C filters is their ability to filter signals without causing considerable loss or distortion in the appropriate frequency range, making them suitable for applications such as power supplies, communication systems, and audio processing. As can be seen in the circuit diagram of the L-C filter in Fig. 6.

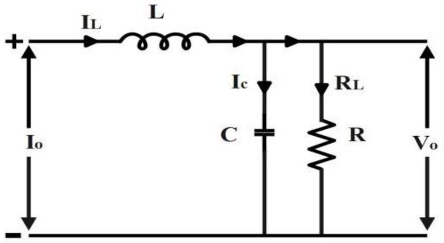


Fig. 6. Circuit of L-C filter

TABLE II: Key parameters of L-C filter

Parameters	***Values***
Inductance (L2)	4e-3
Capacitance (C3)	0.5e-3
Load (R)	25

6. Modeling of Solar PV System

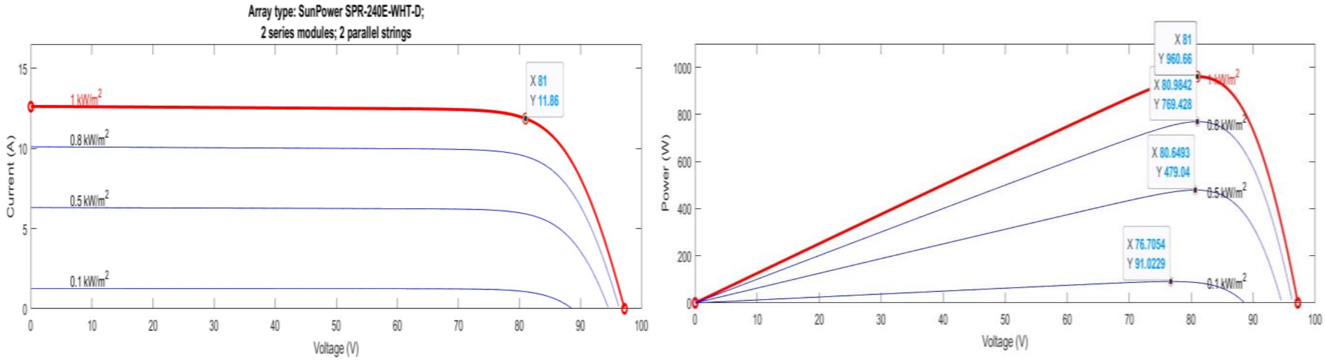
TABLE III: Key Parameters of SunPower SPR-240-WHT-U

Module: *SunPower SPR-240-WHT-U*	
Parameters	***Values***
Maximum Power (W)	240.165
Cells per module (Ncell)	72
Open circuit voltage Voc (V)	48.6
Short-circuit voltage Isc (A)	6.3
Voltage at maximum power point Vmp (V)	40.5

Current at maximum power point Imp (A)	5.93
Temperature coefficient of Voc (%/degree C)	-0.31
Temperature coefficient of Isc (%/deg.C)	0.016

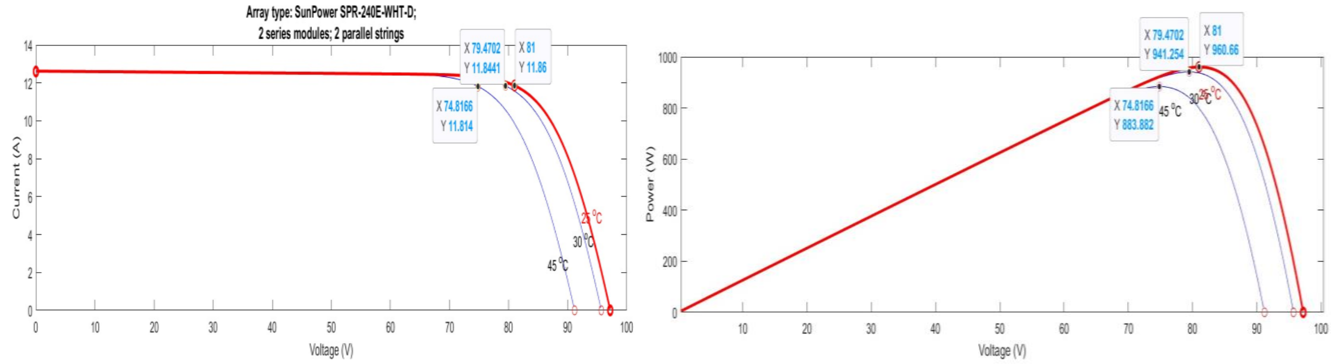
The parameters and values of the SunPower SPR-240-WHT-U PV panel good technology advancement in this PV module system, are shown that Table-III. The I-V and P-V curve graphs obtained under various different solar irradiation and temperature (T) are shown in Fig. 7 and 8 scenarios. The solar panel cell threads, meticulously placed value 2x2 matrix series and parallel strings, provide a maximum output power of around 240 W. Similarly, at 1 kw/m2, the MPP was determined to be 960 W. After thorough testing, the proposed method is intended to properly determine the MPP, the point at which the PV system runs at its highest efficiency under comparable operating conditions.

Simulation of the PV array at various temperatures (T) and constant irradiation of 1 kw/m2 reveals the PV system's exceptional flexibility, resulting in the I-V and P-V properties. Fig. 8 shown that increasing cell operating temperature decreases PV array power (W) and voltage (V). Similarly, at 25℃, the temperature (T) was 960 W, demonstrating the system's consistency and dependability under various condition.



(a) (b)

Fig. 7. (a) & (b): I-V & P-V characteristics of the PV array at constant irradiation



(a) (b)

Fig. 8. (a) & (b): I-V and P-V characteristics of the PV array at constant temperature

7. Proposed Simulation & Results

It can be further improved by creating and designing a simulation model with the help of MATLAB/Simulation software, this software gives me easy access to libraries to model different types of circuits and components. The circuit is modulated with different components by connecting it to a PV solar panel. The Boost Converter and MPPT are designed as a separate system along with the solar panel in the model, which helps in increasing the voltage for its power. The simulation models are being compared in different ways and some models, the ideal power and PV power efficiency are also tracked by the algorithm. In the first model, an inverter is added along with a Boost Converter which works to store energy in the battery and is connected to the PV system, which is given in Fig. 9. This model works to increase the power efficiency with its P&O MPPT tracking. After fully developing the second model, it modeled the standard solar radiation block in the first model with the signal builder, as shown in Fig. 10. Now, one can run this model and get the power output values of the overall system efficiency. When connected to the PV module, it significantly enhances efficiency by regulating input and output values, thereby ensuring optimal performance of the system. This understanding of the system's components is vital to our work. Furthermore, we have developed a new signal model for the solar irradiation source, which we believe will capture your interest with its potential benefits and assist us in determining the overall efficiency. To coordinate the PV output with the stack, the converter is enabled by MPPT calculations through the use of a pulse width balancing generator. Constant temperatures of 25°C, 30°C, and 45°C have been used with varying solar radiation values at the input of the PV module. The duty cycle has been kept from 0.00 to 0.96 to track the PV module to its maximum power with MPPT at 5kHz and the average efficiency at 50Hz with the algorithm to track its maximum value. The simulation used a model run time of 1.5 to 4 seconds. The primary function of the MPPT algorithm is to optimize the efficiency of solar cell power transfer, which is directly affected by the amount of sunlight reaching the solar panels, to extract the maximum possible energy.

To optimize the power of the PV panel, its output power can be provided as 1000 W/m2, 800 W/m2, 500 W/m2, and 100 W/m2, resulting in a maximum power of about 960W, 769W, 479W and 91W.

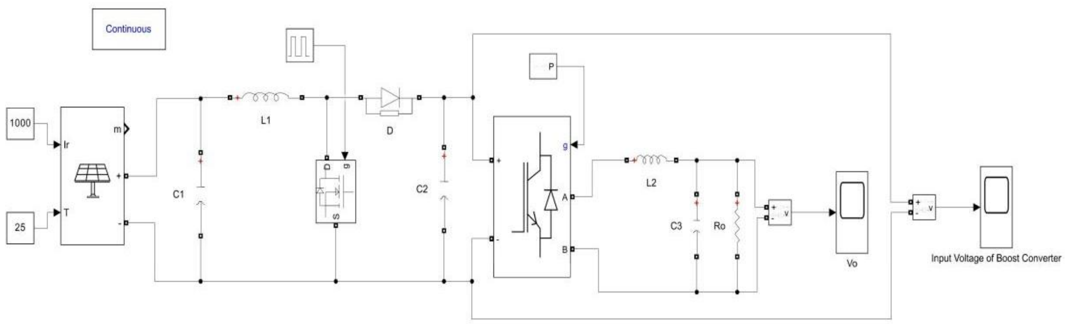


Fig. 9. First model of P&O MPPT algorithm with a DC-DC Boost Converter and DC-AC inverter

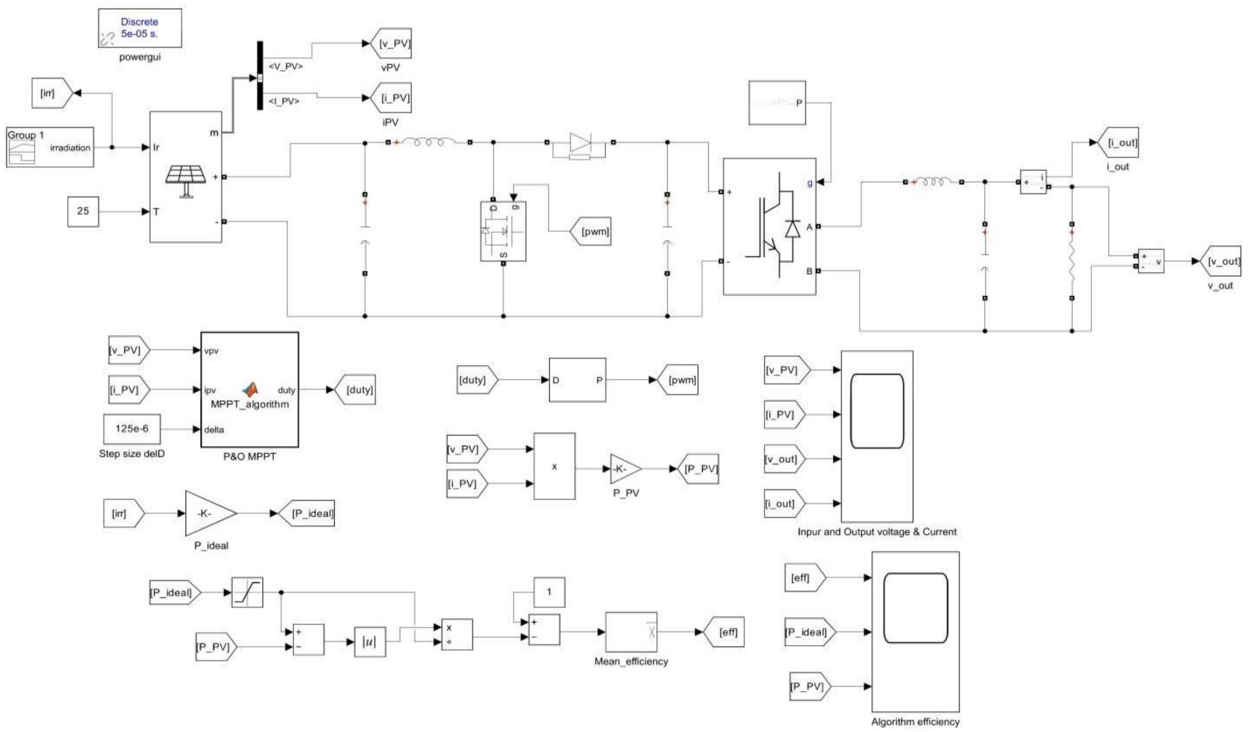


Fig. 10. Second model of P&O MPPT algorithm with a DC-DC Boost Converter and DC-AC inverter

8. Results

When voltage is supplied to the Boost Converter in the input system its voltage increases as can be seen in Fig. 11. The output voltage appears as a sine waveform as can be seen in Fig. 12. In the PV array system when it is run throughout the system then firstly the input and output voltage and current are shown in Fig. 13. After preparing the simulation model it shows the result of its overall power system efficiency in Fig. 14. In this PV system, its power efficiency is increased by combining the voltage with a DC-DC Boost Converter with DC-AC inverter to get the maximum output power voltage. In the PV system, an input of 960 W with 1kw/m2 is tracked by the algorithm. Using the signal builder in solar radiation results in an overall system efficiency as shown in Fig. 14, with a good efficiency of approximately 90-97%.

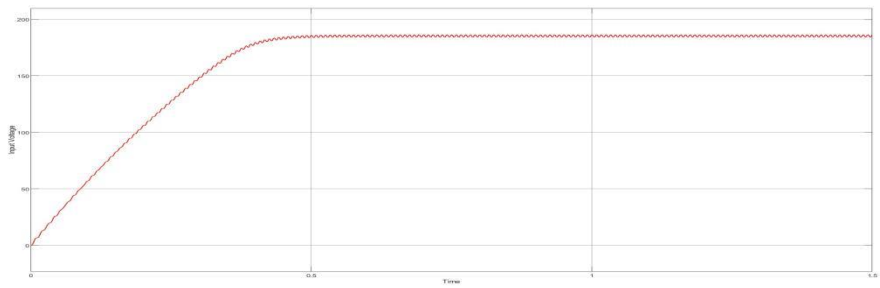
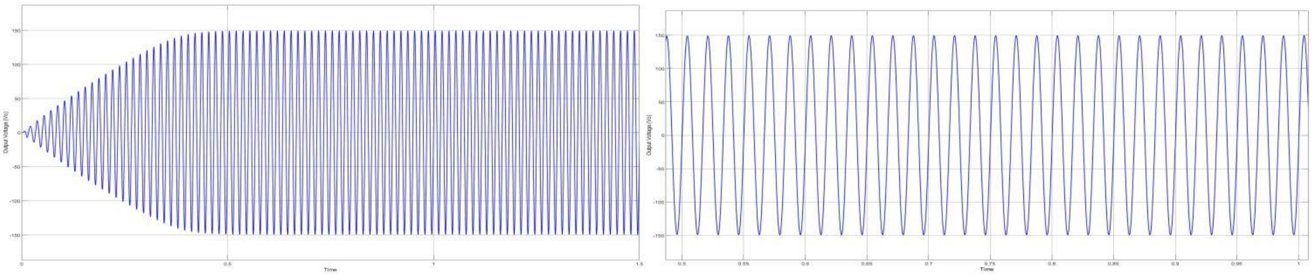
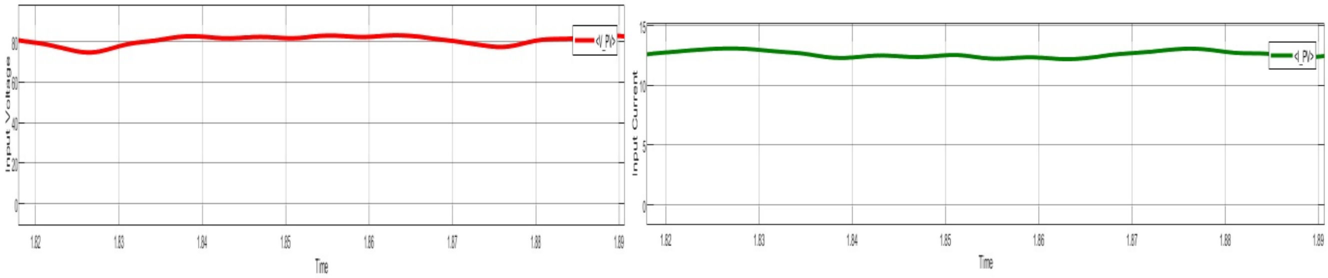


Fig. 11. Input voltage of Boost Converter

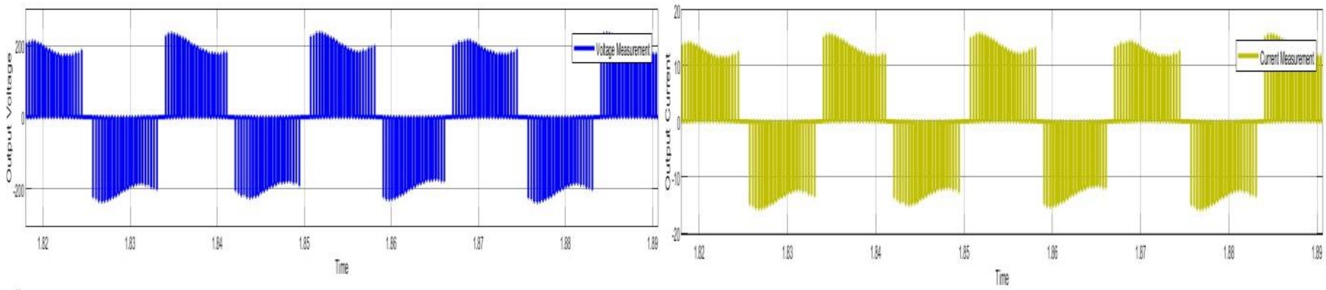


(a) (b)

Fig. 12. Output voltage of DC-AC inverter

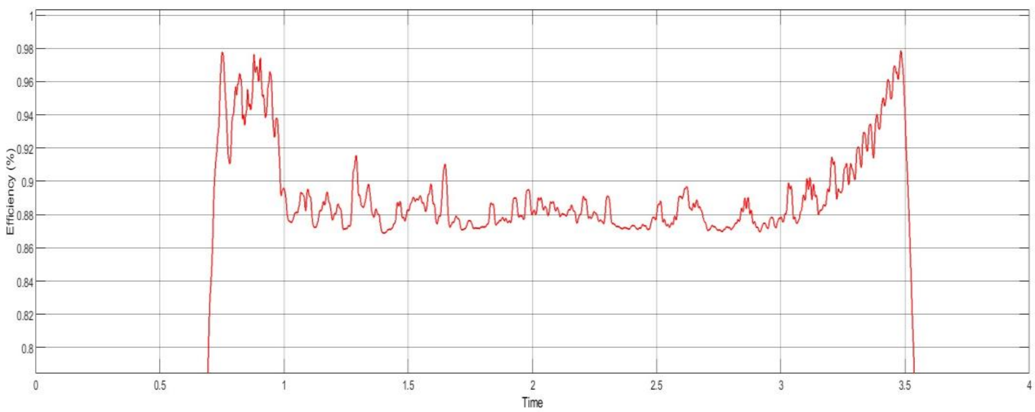


(a) (b)

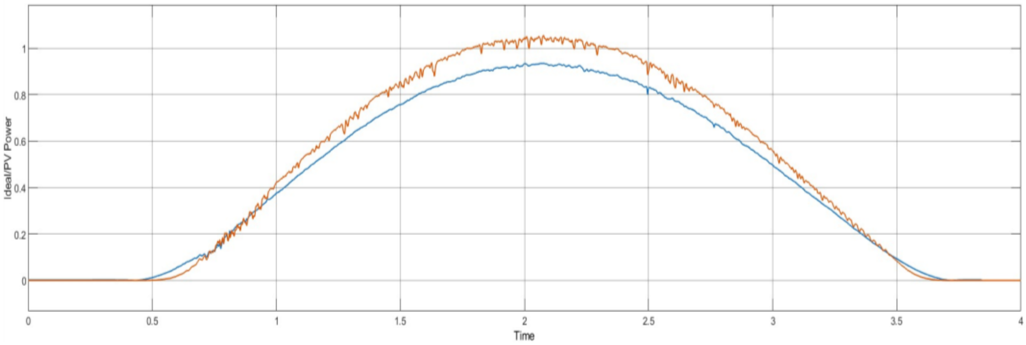


(b) (d)

Fig. 13. (a), (b), (c) & (d) Input & Output Voltage and Current



(a)



(b)

Fig. 14. (a) & (b) Overall system tracking efficiency P&O MPPT algorithm

9. Conclusion

This paper concludes that the DC-DC Boost Converter into the inverter at the load performs greater efficiency when the duty cycle is varying. The efficiency improves significantly as the maximum power increases along with the duty cycle. Fig. 14 indicate that MPPT is used to obtain the optimum output power. Through the increase in power output and voltage, the system has achieved an overall system tracking efficiency of approximately 90-97% using the P&O MPPT tracking algorithm.

References

1. Layth Hazim Majida, Hamid Hazim Majidb and Hussein Fawzi Hussein, “Analysis of Renewable Energy Sources, Aspects of Sustainability and Attempts of Climate Change”, American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS) (2018) Volume 43, No 1, pp 22-32.
2. Neetu Singh, “Review Paper on Renewable Energy”, International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 11 Issue IX Sep 2023.
3. Essam Hendawi, And Mahrous Ahmed, “Simulation And Simple Implementation Of Single Phase Pwm Inverter With Minimum Harmonics”, International Journal Of Industrial Electronics And Electrical Engineering, Issn: 2347-6982 Volume-4, Issue-2, Feb.-2016.
4. Salam Waley Shneen, Fatin Nabeel Abdullah and Dina Harith Shaker, “Simulation model of single phase PWM inverter by using MATLAB/Simulink”, International Journal of Power Electronics and Drive Systems (IJPEDS) Vol. 12, No. 1, Mar 2021, pp. 212~216 ISSN: 2088-8694.
5. S.Daison Stallon, K.Vinoth Kumar, Dr. S.Suresh Kumar and Justin Baby, “Simulation of High Step-Up DC–DC Converter for Photovoltaic Module Application using MATLAB/SIMULINK”, International Journal of Intelligent Systems and Applications, June 2013.
6. Prof R. Kameswara Rao,P. Srinivas and M.V. Suresh Kumar, “DESIGN AND ANALYSIS OF VARIOUS INVERTERS USING DIFFERENT PWM TECHNIQUES”, International Conference on Innovations in Electrical & Electronics Engineering (ICIEEE-2014), ISSN (e): 2319-1813 ISSN (p): 2319-1805.

7. V.K. Saxena and Abhishek Ranjan, "MATLAB Simulink for single phase PWM inverter in an uninterrupted power supply", International Journal of Modern Engineering Research (IJMER), ISSN: 2249–6645, Vol. 4, Iss. 6, June 2014.
8. Hami Colak and Ersan Kabalci, "Implementation of Energy-efficient Inverter for Renewable Energy Sources", Electric Power Components and Systems, 41:31-46, 2013, DOI: 10.1080/15325008.2012.732656.
9. Mr. Ritesh C. Ujawane, Mr. Parag G. Shewane, MR. Nitin Choudhary , Mr. Smitesh Bobde, Mr. Rahul and R Jichakar, "Simulation of Single Phase Inverter", International Journal Of Innovative Research In Technology (IJIRT), Volume 6 Issue 12, ISSN: 2349-6002, May 2020.
10. K. A. Sunitha , G Prem Kumar, Nidhi Priya and Jatin Verma, "Design of High Efficient MPPT Solar Inverter", MATEC Web of Conferences 14004 (2017) ICMAA 2017, DOI: 10.1051/matecconf/201710814004.
11. Hussein A. Hussein, Ali J. Mahdi and Thamir M. Abdul-Wahhab, "Design of a Boost Converter with MPPT Algorithm for a PV Generator Under Extreme Operating Conditions", Engineering and Technology Journal 39 (10) (2021) 1473-1480.
12. N. Kanagaraj and Mohammed Al-Ansi, "Maximum Power Extraction Control Algorithm for Hybrid Renewable Energy System", Computer Systems Science & Engineering, April 2022.
13. Tejan L. and Divya K Pai, "Boost Converter With Mppt And Pwm Inverter For Photovoltaic System", International Journal of Electrical and Electronic Engineering & Telecommunications, ISSN 2319 – 2518, Vol. 1, No. 1, March 2015.
14. N.Dinesh kumar, S.Dhivya, B.Ganga and R.Palani, "Simulation and Analysis Of DC-DC Boost Converter Using PSPICE Software Program", International Journal of Creative Research Thoughts (IJCRT), Volume 12, Issue 4, April 2024, ISSN: 2320-2882.